True Multi-Floor Map Matching in Indoor Environments for Mobile Platforms

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ABSTRACT

In many applications, maps are known before the actual deployment. They greatly ease the navigation task for indoor pedestrian navigation. Map-Matching algorithms are used to fit an estimated path into these maps. For example, mathematical tools like Sequential Monte Carlo (SMC) methods, based on a 2 dimensional particle filter: A large number of SMC particles is distributed over the digital map where rooms are represented as impenetrably walls. The particles approximate the probability density function of the user's position, moving into the direction of the estimated path and if a SMC particle collides with a wall, it is excluded from the Monte Carlo simulation. On behalf of computation time, the degree of freedom of this formerly 3D problem normally is reduced to 2D, so the height of a trajectory is not considered. Depending on the map and walked path, SMC map matching can completely eliminate estimation drift. Even an unknown starting point can be estimated after some time. To extend this to multi floor map matching, other research groups introduce an additional virtual floor between two floors representing the projection of the staircase. Different floor level areas and the different areas for each step of the staircase have different heights, respectively. But the estimated height is not used but is only projected for the ouput. Furthermore, vertical movements like elevators or ladders in industrial environments cannot be modeled.
In this paper, we propose a new map representation where rooms are represented as rectangles with additional information like doors or transitions. Staircases are represented as sloping rectangles and elevators and ladders as vertical rectangles where the user can walk along respectively above. Now, having a good height estimation from IMU and barometer measurements, this additional constraint is used for each particle, finally matching the estimated trajectory to the multi-floor map. Even slightly drifting height profiles due to barometric drift can be processed in our approach.
The new map representation is also very profitable for personal guidance in the new map.
We will present simulation results as well as real data results showing our real-time implementation including map matching but also guidance. The low computational burden will also be discussed.

KEYWORDS: Pedestrian Navigation, Indoor Navigation, Map Matching, Particle Filters, Multi-floor